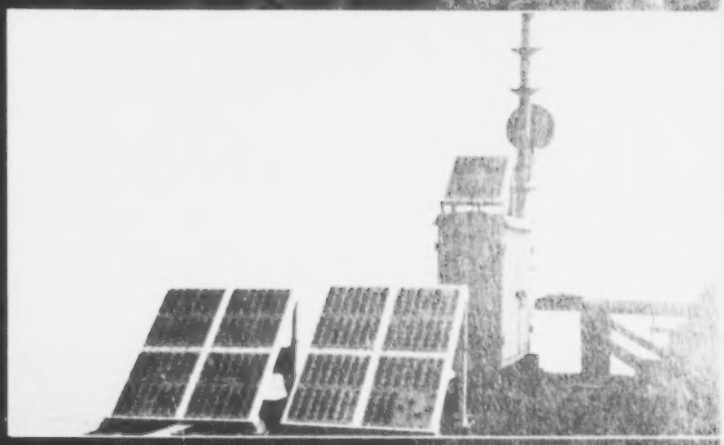
Energy Information Administration

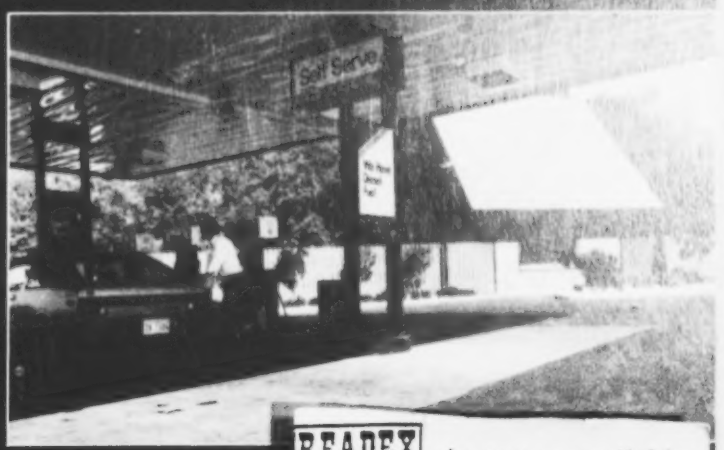
DOE/EIA-0174(89)

989

Solar Collector Manufacturing Activity 1989

March 1991





E3.19/2:

READEX FICHE best copy available

This publication may be purchased from the Superintendent of Documents, U.S. Government Printing Office. Purchasing information for this or other Energy Information Administration (EIA) publications may be obtained from the Government Printing Office or EIA's National Energy Information Center. Questions on energy statistics should be directed to the Center by mail, telephone, or telecommunications device for the hearing impaired. Addresses, telephone numbers, and hours are as follows:

National Energy Information Center, EI-231
Energy Information Administration
Forrestal Building, Room 1F-048
Washington, DC 20585
(202) 586-8800
Telecommunications Device for the
Hearing Impaired Only: (202) 586-1181
8 a.m. - 5 p.m., eastern time, M-F

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 783-3238
FAX 1-202-275-0019
8 a.m. - 5 p.m., eastern time, M-F

Cover Photos:

Solar panels activate signals on the Norfolk and Southern Railway. Photo is courtesy of the Norfolk and Southern Railway Company, Norfolk, Virginia.

Solar power provides hot water and heat for a home in Shenadoah, Georgia.

Photovoltaic cells provide operating power for a gas station in Chicago, Illinois.

Released for Printing: March 20, 1991

DOE/EIA-0174(89)
Distribution Category UC-98

Solar Collector Manufacturing Activity 1989

March 1991

Energy Information Administration
Office of Coal, Nuclear,
Electric and Alternate Fuels
Washington, DC

This report was prepared by the Energy Information Administration, the independent statistical and analytical agency within the Department of Energy. The information contained herein should not be construed as advocating or reflecting any policy position of the Department of Energy or any other organization.

Contacts

This report was prepared in the Nuclear and Alternate Fuels Division; Office of Coal, Nuclear, Electric and Alternate Fuels; Energy Information Administration; U.S. Department of Energy. Questions concerning the contents of the report may be directed to the Project Manager, James Disbrow (202/254-5558); or Howard Walton (202/254-5500), Director of the Nuclear and Alternate Fuels Division.

Preface

This report was prepared by the Energy Information Administration, the independent statistical and analytical agency within the U.S. Department of Energy in cooperation with the Office of Conservation and Renewable Energy. The report presents data on producer shipments and end uses obtained from manufacturers and importers of solar thermal collectors and photovoltaic modules. It provides annual data necessary for the Department of Energy to execute its responsibility to (1) monitor activities and trends in the solar collector manufacturing industry, (2) prepare the National Energy Strategy, and (3) provide information on the size and status of the industry to interested groups such as the U.S. Congress, Government agencies, solar energy specialists, manufacturers, and the general public.

Contents

	Page
Executive Summary	vii
1. Introduction	1
Purpose and Background	1
History and Legal Authority	1
2. Solar Thermal Collector Manufacturing	3
Industry Status	3
Total Producer Shipments	4
Shipments of Medium- and Low-Temperature Collectors	4
Industry Concentration	5
Shipments of Collectors by State of Manufacture	6
Shipments of Collectors by State of Destination	6
Shipments by End Use	8
Shipments by Market Sector	9
Value of Shipments	9
Imports	9
Exports	9
Related Activities	10
Employment	10
3. Photovoltaic Module Manufacturing	13
Photovoltaic Module Manufacturers	13
Value of Shipments	13
Total Producer Shipments	14
Shipments by End Use	14
Shipments by Market Sector	15
Exports and Imports	15
Technology Status and Photovoltaic Industry Plans	15
Appendices	
A. Survey Methodology	19
B. Survey Questionnaires and Instructions	25
C. Respondents to the Annual Solar Thermal Collector Manufacturers Survey	43
D. Respondents to the Annual Photovoltaic Module Manufacturers Survey	47
Glossary	49

Tables

		Page
1.	Solar Thermal Collector Shipments, 1974-1989	3
2.	Shipments of Low- and Medium-Temperature Solar Thermal Collectors by Type, 1980-1989	5
3.	Shipments and Market Shares of the Ten Largest Manufacturers and Importers of Solar Thermal Collectors, 1982-1989	6
4.	Destination of Solar Thermal Collector Shipments by State or Territory, 1989	7
5.	Top Four States and the Territory Ranked by Destination of Solar Thermal Collector Shipments, 1989	7
6.	Shipments of Solar Thermal Collectors by Type and End Use, 1989	8
7.	Shipments of Solar Thermal Collectors by Type and Market Sector, 1989	9
8.	Value of Shipments and Average Value of Solar Thermal Collectors, 1989	10
9.	Origin of U.S. Imports and Destination of U.S. Exports of Solar Thermal Collectors, 1989	10
10.	Related Activities Reported by Manufacturers and Importers of Solar Thermal Collectors, 1987-1989	11
11.	Distribution of Solar Thermal Collector Manufacturers and Importers by Solar-Related Sales as a Percentage of Total Sales, 1989	11
12.	Number of Solar Thermal Manufacturers Expecting to Introduce New Solar-Related Products in 1990	11
13.	Destination of Solar Collectors Immediately After Manufacturing, 1989	12
14.	Annual Photovoltaic Module and Cell Manufacturing Activity, 1982-1989	13
15.	Value of Shipments and Average Value of Photovoltaic Modules/Cells by Type, 1989	14
16.	Annual Photovoltaic Shipments by Module and Cell Type, 1989 and 1988	14
17.	Photovoltaic Module and Cell Shipments by End Use, 1989	15
18.	Photovoltaic Module and Cell Shipments by Market Sector, 1989	15
19.	Number of Photovoltaic Module Manufacturers Expecting to Introduce New Photovoltaic-Related Products Within Year of Survey	16
20.	Number of Photovoltaic Module Manufacturers Involved in Photovoltaic-Related Activities, 1989 and 1988	16
A1.	Number of Reporting Companies and Shipments, 1984-1986	20
A2.	Shipments for Companies Reporting in All Years, 1984-1986	20
A3.	Status of Solar Thermal Collector and Photovoltaic Module Manufacturers, 1989 Survey	21

Executive Summary

Introduction

This report presents a statistical profile of the solar thermal collector and the photovoltaic module manufacturing industries during 1989. The profile includes information on the number of manufacturers and importers; the amount and value of solar collector and photovoltaic module shipments[1] by type of collector; market sector and end-use information; and employment and product information. This report for the first time includes an accounting of the manufacture and shipments of parabolic trough collectors used by independent power producers to generate electricity for the electric grid. However, only total shipment data are reported to avoid disclosure of company-specific information. The statistics on the shipments of collectors for this use have been assembled for the 1984-through-1989 period and are included in the information on solar thermal collector shipments presented in this report.

Solar Thermal Collector Manufacturing Activity, 1989

Shipments of solar thermal collectors in 1989 were reported by 44 firms, totaling 11.48 million square feet. This represents an increase of 3.31 million square feet relative to 1988. One important factor causing this increase was the liquidation sales of a large company's stock at below manufacturer cost. Approximately 1.23 million square feet of collectors shipped in 1989 were imported and approximately 461,000 square feet were exported. Low-temperature collectors comprised 37 percent of total shipments, medium- and high-temperature solar thermal collectors accounted for the remaining shipments.

Activity in 1989 is summarized below:

- Total shipments of solar thermal collectors were higher in 1989 than in any year since 1986.
- Shipments of low-temperature collectors increased from 3.3 million square feet in 1988 to approximately 4.3 million square feet in 1989--a 29-percent increase.
- Shipments of medium-temperature collectors increased from 0.73 million square feet in 1988 to 2.0 million square feet in 1989, a 172-percent increase.
- The number of firms shipping solar thermal collectors decreased from 51 in 1988 to 44 in 1989.
- The average shipment of medium-temperature collectors increased from 16,000 square feet in 1988 to 55,000 square feet in 1989. The average shipment of low-temperature collectors increased from 416,000 square feet to 428,000 square feet during the same period.
- Shipments by market sector for all types of collectors were dominated by shipments to the residential sector, which accounted for 51 percent of all shipments.

Photovoltaic Module and Cell Manufacturing Activity, 1989

In 1989, total shipments of photovoltaic modules and cells were 12,825 kilowatts by 17 companies. These modules and cells are used in a wide range of applications, from toys and calculators to electric power generation. The value of shipments in 1989 was $61.1 million, averaging $5.14 per watt for modules and $3.06 for cells. Single-crystal silicon modules accounted for about 56 percent of all photovoltaic module shipments in 1989. The next most prevalent type of module shipped was the cast- and ribbon-type, followed by the amorphous silicon type.

The largest market sector for photovoltaic shipments in 1989 was in industrial applications, with 31 percent of the total, followed by commercial applications with 30 percent of the total.

[1]Shipments are defined as solar collector or photovoltaic modules or cells shipped for final use or for resale by other organizations.

1. Introduction

Purpose and Background

This report presents data on shipments and end uses of solar thermal collectors and photovoltaic modules. The solar thermal collector manufacturing data are summarized for the 16-year period from 1974 through 1989, and photovoltaic module and cell data for the 1982 through 1989 period, with detailed information presented for 1989. Appendix A explains the limitations of the 1985 survey.

In this report, shipment size refers to the area, in square feet, of solar thermal collectors shipped, and to the amount, in peak kilowatts, of photovoltaic modules shipped. The 1989 data were collected on Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." Appendix B contains copies of the survey forms and instructions. Appendices C and D list the manufacturers of thermal collectors and photovoltaic modules that responded to the 1989 survey and granted permission for their names and addresses to appear in the report.

History and Legal Authority

EIA and its predecessor organizations began conducting voluntary telephone surveys of manufacturers of solar thermal collectors in 1975. The goal of these surveys was to obtain information on manufacturing activity in the industry. The first survey covered manufacturing activity for 1974. Succeeding surveys were conducted every 6 months to inform both public and private interests of trends in this industry. The mandatory reporting of data under Public Law 93-275 began with the period covering July through December of 1978. Since 1982, the survey has been conducted annually rather than semiannually.

2. Solar Thermal Collector Manufacturing

Industry Status

The shipments of solar thermal collectors increased by 40 percent in 1989 compared with 1988 despite the decline in active participants. One important factor causing this increase was the liquidation sales of a large company's stock at less than manufacturing costs.

As Table 1 shows, the market was strong and growing from the mid-1970's to the early 1980's. The market remained strong through 1984. (No survey was conducted during 1985, see Appendix A). Solar collector shipments, including exports and imports, declined from an average of more than 18 million square feet between 1980 and 1984 to 8 million square feet from 1986 through 1988.

The decline began with the expiration of the 40-percent residential energy tax credit and the 15-percent business energy tax credit at the end of 1985, and intensified with a drop in oil prices in 1986. Reinstatement of the business energy tax credit in 1986, at the 15-percent level for 1986 and at 12 percent for 1987 through 1989, had little effect since the market for commercial solar systems had always been small.

Some representatives of solar industry associations are optimistic about the future of the industry despite the expiration of tax credits and the decline in number of active participants. Although inactive in 1989, twenty companies in this year's survey expressed future plans to manufacture and ship solar thermal collectors.

Table 1. Solar Thermal Collector Shipments, 1974-1989

Year	Number of Companies Reporting Shipments	Number of Nonrespondents	Collector Shipments (thousand square feet)		
			Total Shipments[a]	Imports	Exports
1989	44	0	11,482	1,233	461
1988	R51	0	R8,174	614	158
1987	R59	0	R7,269	691	182
1986	R98	0	R9,360	473	224
1985[b]	NA	NA	NA	NA	NA
1984	R225	0	R17,191	621	348
1983	203	21	[c] 16,828	511	159
1982	265	9	[c] 18,621	418	455
1981	203	79	[c] 20,133	196	771
1980	233	43	[c] 19,398	235	1,115
1979	349	0	14,251	290	855
1978	340	0	10,860	396	840
1977	321	0	10,312	NA	NA
1976	186	0	5,801	NA	NA
1975	131	0	3,743	NA	NA
1974	45	0	1,274	NA	NA

[a] Total Shipments include collectors imported and exported and shipped for end use.
[b] Incomplete data (see Appendix A).
[c] Includes imputation for nonrespondents. See 1988 report for method of imputation.
NA = Not available.
R = Revised. For years 1984, and 1986 through 1988 the revised numbers include shipments of parabolic trough collectors to independent power producers to generate electricity for the electric grid.
Sources: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," 1974-1989 (Form CE-63A, 1985-1989; Form EIA-63, 1978-1984; telephone survey by the Federal Energy Administration, 1974-1977).

Some collectors can be bought for as little as $40 per square foot installed but most are still in the range of $55 to $80 per square foot.[2] The price for low-temperature collectors, used mostly for residential pool heating, is as little as 1/10 that of the medium-temperature collectors.[3]

Pool-heating collectors never qualified for the Federal energy tax credit and thus were not adversely affected by its elimination. Pool-heating collectors are simpler, less technically demanding and more reliable systems than medium-temperature collectors. In some regions, low-temperature collectors provide a cost-effective alternative to electric heating.

Between 1984 and 1988, the number of manufacturers or active industry participants declined, from 225 firms in 1984 to 51 in 1988 (Table 1). The number of active industry participants continued to decline through 1989, dropping to 44.

The 1989 survey data indicate several notable changes in the industry. These are summarized below and are further discussed in the following sections.

- Shipments of collectors increased from 8.17 million square feet in 1988 to 11.48 million square feet, an increase of 40 percent.
- Shipments of collectors in the medium-temperature category increased from 732,000 square feet in 1988 to 2.0 million square feet--an increase of 172 percent (Table 2). This increase is due partly to a large shipment of collectors at a very low price.
- Shipments of low-temperature collectors increased by 29 percent, from 3.3 million square feet in 1988 to 4.3 million square feet.

Total Producer Shipments

In 1989, shipments of all types of solar thermal collectors, low-, medium-, and high-temperature, totaled 11.48 million square feet, including imports, shipped by 44 companies (Table 1). In 1988, 8.17 million square feet were shipped by 51 companies.

High-temperature collectors operate above 180° Fahrenheit. They are predominently parabolic trough collectors used by independent power producers to generate electricity for the electric grid. All data on high-temperature collectors have been withheld to protect the confidentiality of respondents. However, they are included in the total shipment data.

The total volume of imports in 1989 was 1.23 million square feet, compared with 814,000 square feet in 1988. The total volume of exports in 1989 was 461,000 square feet, compared with about 158,000 square feet in 1988.

Shipments of Medium- and Low-Temperature Collectors

In Table 2, the total shipments of solar thermal collectors are divided into two categories:

- Low-temperature collectors provide low-grade heat, less than 110° Fahrenheit, through either metallic or nonmetallic absorbers for applications such as swimming pool heating and low-grade water and space heating.
- Medium-temperature collectors provide mid-to-high grade heat (greater than 110° Fahrenheit, usually 140 - 180° Fahrenheit), either through glazed flat-plate collectors using air or liquid as the heat transfer medium or through concentrator collectors that concentrate the heat to levels greater than "one sun." These include evacuated tube collectors.

In 1989, shipments of low-temperature collectors totaled 4.3 million square feet, those of medium-temperature collectors totaled 2.0 million square feet, compared with 3.3 million square feet and 732,000 square feet, respectively, in 1988. The average annual shipment of low-temperature collectors was approximately 428,000 square feet in 1989, compared with 416,000 square feet in 1988. The average annual shipment of medium-temperature collectors in 1989 was about 55,000 square feet, compared with 16,000 square feet in 1988. This change is primarily due to liquidation of a large volume of stock by one company.

[2]Department of Energy, Office of Solar Heat Technology, "Solar Buildings Industry Update," Report by Science Applications International Corporation and Mueller Associates, Inc. under Contract DE-AC01-86CE30844, p. 4. Note that the cost data in the survey are for collector costs, not system costs. System costs include such items as the storage tank and installation. Typically, the system cost is two to three times the collector cost. These cost data are for flat-plate systems with relatively simple designs. Evacuated tube collectors, which operate at higher efficiencies, cost 50-100 percent more. Costs decline as system size increases for all types of units.

[3]Pool-heating systems typically have no storage tanks and require much less installation time and fewer materials than medium-temperature collectors for domestic water heating.

Table 2. Shipments of Low- and Medium-Temperature Solar Thermal Collectors by Type, 1980-1989
(Thousand Square Feet)

Year/Data Source	Solar Thermal Collector Shipments			
	Low-Temperature		Medium-Temperature	
	Total Shipments	Average Annual Shipments per Manufacturer	Total Shipments	Average Annual Shipments per Manufacturer
1989				
Reported	4,283	428.3	1,989	55.3
1988				
Reported	3,326	415.8	732	16.2
1987				
Reported	3,157	263.1	957	19.1
1986				
Reported	3,751	170.5	1,111	12.8
1985[a]	NA	NA	NA	NA
1984				
Reported	4,479	93.3	11,939	58.0
1983				
Reported	3,526	–	11,678	–
Estimated	1,327	–	297	–
Total	4,853	88.2	11,975	66.9
1982				
Reported	7,370	–	11,002	–
Estimated	106	–	143	–
Total	7,476	122.6	11,145	44.9
1981				
Reported	8,339	–	10,023	–
Estimated	338	–	1,433	–
Total	8,677	115.7	11,456	43.6
1980				
Reported	11,299	–	6,468	–
Estimated	934	–	697	–
Total	12,233	154.8	7,165	28.7

[a] Incomplete data (see Appendix A).
NA = Not available.
Sources: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," 1980-1989 (Form CE-63A, 1985-1989; Form EIA-63, 1980-1984).

Industry Concentration

Of the 11.48 million square feet of thermal collectors shipped in 1989, 11.07 million square feet (96.4 percent) were manufactured and shipped by the 10 largest companies (Table 3). This compares with 7.92 million square feet out of a total of 8.17 million square feet (96.9 percent) shipped by the 10 largest companies in 1988. This shows a continuation of the industry concentration first observed in 1986.

The five largest companies were responsible for shipping approximately 9.7 million square feet in 1989, representing 84.9 percent of all shipments of solar thermal collectors.

Table 3. Shipments and Market Shares of the Ten Largest Manufacturers and Importers of Solar Thermal Collectors, 1982-1989

Year/ Company Rank	Solar Thermal Collectors Shipped (thousand square feet)	Percent of Industry Total
1989		
1-5	9,748	84.9
6-10	1,321	11.5
1-10	11,069	96.4
1988		
1-5	R7,585	92.8
6-10	335	4.1
1-10	R7,920	96.9
1987		
1-5	R6,371	87.6
6-10	499	6.9
1-10	R6,870	94.5
1986		
1-5	R7,771	83.0
6-10	785	8.4
1-10	R8,556	91.4
1985[a]	NA	NA
1984		
1-5	R6,092	35.4
6-10	2,605	15.2
1-10	R8,697	50.6
1983		
1-5	5,919	35.2
6-10	2,752	16.4
1-10	8,671	51.5
1982		
1-5	6,320	33.9
6-10	2,560	13.7
1-10	8,880	47.7

[a] Incomplete data (see Appendix A).
NA = Not available.
R = Revised. For years 1984, and 1986 through 1988 shipments were revised to include parabolic trough collectors used by independent power producers.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," 1982-1989 (Form CE-63A, 1985-1989; Form EIA-63, 1982-1984).

Shipments of Collectors by State of Manufacture

Solar thermal collectors were reported to have been manufactured in 17 States and Puerto Rico. Because of possible disclosure problems, data for only the most active States are listed in this report. California was the largest producer, with 7.36 million square feet. The next three States (New York, Tennessee, and Florida) shipped a combined total of 2.26 million square feet. Two additional States and Puerto Rico each had shipments of over 10,000 square feet, five States had shipments between 1,000 and 10,000 square feet, and six States had shipments between 1 and 1,000 square feet.. No collector manufacturing activities were reported for 34 States, the Virgin Islands, and the District of Columbia.

Shipments of Collectors by State of Destination

Shipments of solar thermal collectors were reported to have been made to 36 States and Puerto Rico (Table 4). According to the survey, 14 States (Alaska, Arkansas, Delaware, Idaho, Indiana, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Montana, Nebraska, North Dakota, and South Dakota), the Virgin Islands, and the District of Columbia did not receive collector shipments in 1989. Of the 36 States, 4 received negligible amounts of less than 100 square feet, 7 States received shipments between 100 and 1,000 square feet, and 8 States received shipments between 1,000 and 10,000 square feet. Three States and Puerto Rico received over 100,000 square feet of shipments.

Table 4. Destination of Solar Thermal Collector Shipments by State or Territory, 1989
(Square Feet)

Destination	Total Shipments	Destination	Total Shipments
Alaska	0	Nevada	27,216
Alabama	4,372	New Hampshire	387
Arizona	199,016	New Jersey	47,653
Arkansas	0	New Mexico	41,076
California	6,907,148	New York	49,366
Colorado	12,891	North Carolina	1,465
Connecticut	58	North Dakota	0
Delaware	0	Ohio	7,286
District of Columbia	0	Oklahoma	256
Florida	3,117,225	Oregon	87,525
Georgia	2,270	Pennsylvania	10,418
Hawaii	82,192	Puerto Rico	231,463
Idaho	0	Rhode Island	35
Illinois	25,541	South Carolina	310
Indiana	0	South Dakota	0
Iowa	192	Tennessee	7,286
Kansas	0	Texas	38,195
Kentucky	0	Utah	699
Louisiana	0	Vermont	67
Maine	24,598	Virgin Islands	0
Maryland	37	Virginia	26,937
Massachusetts	8,333	Washington	309
Michigan	19,306	West Virginia	310
Minnesota	0	Wisconsin	9,780
Mississippi	0	Wyoming	4,372
Missouri	25,320		
Montana	0	**U.S./Territory Total**	11,020,910
Nebraska	0	Exports	461,071
		Total Shipments	11,481,981

Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

The States and Territory that received the largest total shipments of solar thermal collectors were: California, Florida, Puerto Rico, Arizona, and Oregon (Tables 4 and 5). California received more than 6.9 million square feet of collectors, about 60 percent of all collector shipments. Florida received 27 percent, the second largest share. California and Florida account for 87 percent of all collector shipments by State of destination (exports excluded), while Puerto Rico, Arizona, and Oregon represent an additional 4.5 percent. In summary, these four States and the Territory received over 92 percent of all collector shipments bound for U.S. markets. The factors that these four States and the Territory have in common are good solar insolation, high electricity costs, and strong demand for low-technology pool heaters.

Table 5. Top Four States and the Territory Ranked by Destination of Solar Thermal Collector Shipments, 1989

Rank/State or Territory of Destination	Total Shipments (thousand square feet)	Percent of Total U.S. Shipments[a]
1. California	6,907	60
2. Florida	3,117	27
3. Puerto Rico	231	2
4. Arizona	199	2
5. Oregon	88	1
Total	10,542	92

[a] Exports excluded.
Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

Table 6. Shipments of Solar Thermal Collectors by Type and End Use, 1989
(Square Feet)

End Use	Low Temperature (Liquid and Air)	Medium Temperature					High Temperature	Other	Total
		Air	Liquid						
	Metallic and Nonmetallic	Medium Temperature	Thermosiphon	Flat Plate (pumped)	Concentrator	Evacuated Tube	Parabolic Dish/Trough		
Pool Heating	4,283,260	0	0	404,768	0	0	0	0	4,688,028
Water Heating	0	0	224,508	1,147,939	W	W	0	0	1,374,147
Space Heating	0	W	W	W	0	W	W	0	205,293
Combined Space and Water Heating	0	W	W	W	0	W	W	0	5,243
Total[a]	4,283,260	202,437	226,582	1,558,232	W	W	W	0	11,481,981

[a] Data for space cooling, process heating, electricity generation, and other end uses as well as for liquid concentrators, evacuated tube, and high-temperature collectors are withheld to avoid disclosure of company-specific information. They are, however, included in the total.

W = Withheld to avoid disclosure of individual company data.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE 63A, 1989.

Shipments by End Use

Shipments of solar thermal collectors by type and according to end use are presented in Table 6.

A large number of the 1989 shipments were for electric generation. This number is withheld because of the few manufacturers in this category. Electric generation aside, during 1989 shipments continued to be concentrated on pool-heating systems, which are generally low-technology designs. A common pool-heating collector is a black plastic or rubber-like sheet where the water circulates through tubing or is sandwiched between layers of absorbing material. The heat of the sun is directly transferred from the black absorbing material to the water circulating throughout it. These systems may use a small pump or a thermosiphon design, in which the temperature gradient in the solar-heated water and cool pool water induces a flow and supplies heated water to the pool. Designs of this type are often termed passive collectors, as opposed to active collectors, which require some type of pump to circulate the water. The survey does not distinguish between active and passive low-temperature collectors.

Following pool heating, the second largest market is for water heating. Most of the water-heating market is supplied by two kinds of medium-temperature systems: thermosiphon and active flat-plate collectors. Pool heating and water heating account for 53 percent of the market (Table 6). Approximately 51 percent of the market is residential (Table 7). The nearly complete dominance of the residential market by pool heating and water heating has been a feature of the solar thermal collector market since its earliest days.

Typical domestic water-heating systems for single-family residences feature from two to four collectors (40 to 80 square feet) and provide 30 to 80 percent of the total water-heating requirements. Unlike a pool-heating system, a domestic water-heating system virtually always has a conventional backup (for example, gas or electric).

Two main technologies are used in the medium-temperature collector systems. The active flat-plate designs use a pump to circulate water through the collector and tank. A smaller percentage of the systems use a thermosiphon design, where the temperature gradient in the water induces circulation without a pump. Other systems represent a small percentage of the market. The collector itself is ordinarily a glass-covered metal box with a heat-absorbing material, for example, nonreflective, black-coated copper, used to capture the solar radiation and transfer the heat to water flowing through the absorber.

Shipments to the remaining end-use categories are very small, as enumerated below:

- Space-heating shipments totaled 205,293 square feet, or about 2 percent of total shipments.
- Combined space and water heating accounted for 5,243 square feet, or less than 0.05 percent of total shipments.
- Data for all other shipments are being withheld to retain confidentiality.

Table 7. Shipments of Solar Thermal Collectors by Type and Market Sector, 1989
(Square Feet)

Market Sector	Low Temperature (Liquid and Air)	Medium Temperature					High Temperature	Other	Total
	Metallic and Nonmetallic	Air	Liquid				Parabolic Dish/Trough		
		Medium Temperature	Thermosi-phon	Flat Plate (pumped)	Concen-trator	Evacuated Tube			
Residential	3,914,961	W	210,022	1,476,152	W	W	0	0	5,804,378
Commercial	368,299	W	W	W	0	W	0	0	423,745
Industrial	0	0	0	W	0	W	0	0	42,050
Utility	0	0	0	0	0	0	W	0	W
Other	0	0	W	0	0	0	W	0	W
Total	4,283,260	202,437	226,582	1,558,232	W	W	W	0	11,481,981

W = Withheld to avoid disclosure of individual company data.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

Shipments by Market Sector

Shipment data for 1989 by market-sector categories and by collector type are provided in Table 7. The largest proportion of solar thermal collectors were shipped to the residential sector in 1988 and 1989, at a rate of 4.0 million square feet in 1988 and 5.8 million square feet in 1989. Most of these were low-temperature metallic and nonmetallic collectors for pool-heating applications, followed by thermosiphon and flat-plate pumped medium-temperature collectors for water heating.

Shipments to the commercial sector showed an increase from 255,000 square feet in 1988 to 424,000 square feet in 1989. The commercial sector generally comprises a large number of small applications, mostly pool heating for hotels, motels, and spas. The water-heating applications are generally for laundries, hotels, and other users of water at medium-temperature.

Shipments to the industrial sector increased from 7,000 square feet in 1988 to 42,000 square feet in 1989.

Value of Shipments

The total value of shipments of solar thermal collectors in 1989 is reported in Table 8. The cost data provided in Table 8 represent the total value received for the collectors only, at the company's net billing price, freight-on-board at the factory. High-temperature collectors accounted for the highest total value in 1989, with $92.5 million in shipments at an average price of $17.75 per square feet. Shipments of low-temperature collectors ranked second with $11.2 million at an average of $2.60 per square feet. Flat-plate collector shipments accounted for $8.6 million in shipments at an average price of $8.26 per square foot. Thermosiphon collectors ranked fourth, with $6.2 million, averaging $27.43 per square foot.

Imports

Imports of solar thermal collectors in 1989 totaled 1.23 million square feet, an increase of 51.4 percent from 814,000 square feet of imports reported in 1988 (Table 1). In 1989, imports accounted for 11 percent of total collector shipments, an increase from the 10 percent reported in 1988. Almost 1.2 million square feet of imported collectors were low-temperature collectors, followed by 33,000 square feet of medium-temperature type. During 1989, four companies reported imports of solar thermal collectors from four countries: United Kingdom, Australia, Israel, and Japan (Table 9).

Exports

Exports of solar thermal collectors totaled 461,000 square feet, or 4 percent of all collectors shipped in 1989 (Table 1). In 1989, about 82,000 square feet of exported collectors were of the low-temperature type. Exports of solar thermal collectors were reported by 6 companies to 14 countries (Table 9). The distribution of exports by country of destination is not reported by the survey.

Table 8. Value of Shipments and Average Value of Solar Thermal Collectors, 1989

Collector Type	Value of Shipments (dollars)	Average Value (dollars per square foot)
Low Temperature		
Liquid and Air	11,157,280	2.60
Medium Temperature		
Air	23,028	* 12.28
Thermosiphon	6,215,739	27.43
Flat Plate	8,556,787	* 8.26
Evacuated Tube	62,421	31.21
High Temperature		
Parabolic Dish and Trough	92,480,000	17.75
Other	0	—
Total	118,497,255	* 10.91

* This number excludes a company buyout that shipped at a liquidation price below the manufacturing cost.
Note: Data for liquid concentrators are withheld to avoid disclosure of company-specific information. Total may not equal sum of components because of independent rounding.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

Related Activities

The 44 companies reporting shipments of solar collectors in 1989 also reported being engaged in one or more of the following activities: collector or system design (30), prototype development (11), prototype systems development (10), wholesale distribution (26), retail distribution (24), and installation (21). Table 10 shows the related activities reported by manufacturers of solar thermal collectors for 1987 through 1989.

Table 11 shows the distribution of firms by solar-related sales volume categories. For most solar thermal collector manufacturers, 52 percent of the respondents, solar-related sales volume represented 90 to 100 percent of their sales. For 21 percent of the reporting manufacturers, solar-related sales volume represented 50 to 89 percent of the sales. Therefore, solar-related sales dominated total sales for more than two-thirds of all manufacturers; 11 percent of the manufacturers reported that solar-related sales represented between 10 and 49 percent of total sales volume, and 16 percent of the firms reported that solar sales represented less than 10 percent of their total revenue.

Some solar collector manufacturing firms indicated that they planned to introduce new products in 1990. Eight manufacturers intended solar-related expansions in the medium-temperature collector category, while five manufacturers targeted the low-temperature collector category (Table 12).

Employment

Employment in the solar-related activities in 1989 was reported by 44 active firms as 900 person-years expended. Thirty-six manufacturers, or approximately 82 percent, had 10 or fewer employees contributing to solar-related activities. Of those firms, 27 reported having 2 or fewer employees in solar-related activities.

Table 9. Origin of U.S. Imports and Destination of U.S. Exports of Solar Thermal Collectors, 1989

Origin of Imports	Destination of Exports		
Australia	British West Indies	India	Philippines
Israel	Canada	Japan	Saudi Arabia
Japan	Chile	Jordan	Taiwan
United Kingdom	El Salvador	Mexico	USSR
	France	New Zealand	

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

Table 10. Related Activities Reported by Manufacturers and Importers of Solar Thermal Collectors, 1987-1989

Type of Activity	Number of Manufacturers Engaged in Activity		
	1989	1988	1987
Wholesale Distribution	26	31	36
Retail Distribution	24	22	27
Collector or System Design	30	30	35
Installation	21	19	26
Noncollector System Components Manufacture	11	19	14
Prototype Collector Development	11	15	17
Prototype Systems Development	10	11	10

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1987-1989.

Table 11. Distribution of Solar Thermal Collector Manufacturers and Importers by Solar-Related Sales as a Percentage of Total Sales, 1989

Percent	Percent of Manufacturers
90-100	52
50-89	21
10-49	11
Less than 10	16
Total	100

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

Table 12. Number of Solar Thermal Manufacturers Expecting to Introduce New Solar-Related Products in 1990

New Product Category	Number of Manufacturers
Low-Temperature Collector	5
Medium-Temperature Collector	8
Special Collector	3
Noncollector Solar System Components	4
Other	3

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

Table 13 presents the destinations and square footage of solar thermal collectors immediately following manufacturing or warehousing. Forty-nine percent of collector shipments were sent directly to end users.

Table 13. Destination of Solar Collectors Immediately After Manufacturing, 1989

Recipient	Amount (square feet)
Exporters	497,088
Wholesale Distributors	4,657,574
Retail Distributors	400,481
Installers	348,771
End Users	5,576,667
Other	1,400
Total	11,481,981

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989.

3. Photovoltaic Module Manufacturing

This chapter presents information on the status of the photovoltaic (PV) manufacturing industry in 1989, and includes: (1) an accounting of the number of companies that manufactured and shipped photovoltaic (PV) modules; (2) total producer shipments, both aggregated and delineated by end use; (3) total PV module exports and imports; and (4) present and potential near-term PV-related activities.[4] The end-use and market sector categories were broadened to reflect activity in the current industry. Only aggregate totals are compared with results from previous years.

Modules are defined as PV cells assembled into panels. Modules are shipped either for final consumption or to another organization for resale. Cells are defined as the unencapsulated semiconductor components of the module. Photovoltaic cells convert solar energy to electricity. Data on PV module and cell shipments presented in this report represent modules manufactured and shipped by U.S. manufacturers for domestic use and for export, as well as imported modules and unencapsulated PV cells exported to other countries. This allows for an accounting of all PV module-related manufacturing in the United States.

Photovoltaic Module Manufacturers

The number of companies that manufacture and sell PV modules and cells increased from 14 in 1988 to 17 in 1989. The total amount of PV modules and cells shipped was 12,825 peak kilowatts, as shown in Table 14 (modules, 10,478; cells, 2,347).

Value of Shipments

The total value for shipments of PV modules and cells was approximately $61.1 million in 1989 and the average price was $5.14 per peak watt (Wp) for modules and $3.06 for cells (Table 15). At these prices, PV modules are cost-effective in certain remote areas and small-power applications, including communications. While these prices have declined sharply over the past decade, it is estimated that module costs of less than $1.50/Wp will be necessary for PV modules to compete with conventional fossil fuels for generating electricity by utilities. As the price of PV modules declines towards that level, other applications could open up and the market for PV modules could expand.

Table 14. Annual Photovoltaic Module and Cell Manufacturing Activity, 1982-1989

Year	Amount Shipped (peak kilowatts)	Number of Active Companies
1989[a]	12,825	17
1988[a]	9,676	14
1987[a]	6,850	17
1986[a]	6,333	17
1985[a]	5,769	15
1984	9,912	23
1983	12,620	18
1982	6,897	19

[a] Does not include shipments of modules for space satellite applications.

Sources: Energy Information Administration, "Annual Photovoltaic Module/Cell Manufacturers Survey," Form EIA-63, 1982-1984; Form CE-63B, 1985-1989.

[4]The survey form was updated in 1989, and the collection of cell data was added.

Table 15. Value of Shipments and Average Value of Photovoltaic Modules and Cells by Type, 1989

Module or Cell Type	Value of Shipments (dollars)	Average Value (dollars per peak watt)	
		Modules	Cells
Crystalline Silicon			
Single-Crystal	32,445,490	4.98	3.17
Cast and Ribbon	17,164,081	4.91	4.00
Thin Film Amorphous Silicon	8,375,000	5.24	2.00
Concentrator Silicon	3,085,000	10.00	0.57
Other	0	NA	NA
Total	61,069,571	5.14	3.06

Note: This table does not include shipments of modules for space satellite applications.
Source: Energy Information Administration, "Annual Photovoltaic Module/Cell Manufacturers Survey," Form CE-63B, 1987-1989.

Table 16. Annual Photovoltaic Shipments by Module and Cell Type, 1989 and 1988

Module or Cell Type	Amount Shipped (peak kilowatts)		Percent of Total	
	1989	1988	1989	1988
Crystalline Silicon				
Single-Crystal	7,207	5,508	56.2	56.9
Cast and Ribbon	3,540	1,856	27.6	19.2
Thin Film Amorphous Silicon	1,628	1,895	12.7	19.6
Concentrator Silicon	450	1	3.5	0.01
Other	0	416	0	4.3
Total	12,825	9,676	100.0	100.0

Notes: This table does not include shipments of modules for space satellite applications. Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, "Annual Photovoltaic Module/Cell Manufacturers Survey," Form CE-63B, 1987-1989.

Total Producer Shipments

Table 16 shows module shipments by type of module for 1988 and 1989. Single-crystal silicon modules and cells continue to be the most widely manufactured type, accounting for 7.2 megawatts (peak), or about 56 percent of U.S. shipments. Cast- and ribbon-type modules and cells accounted for 3.5 megawatts (peak), or 28 percent, and thin-film amorphous silicon modules and cells accounted for 1.6 megawatts (peak), or about 13 percent of total shipments.

Shipments by End Use

Consumer goods (22 percent), remote electrical generation applications (20 percent), and communications (20 percent) are the most important end uses (Table 17). Much of the other usage is for activities in the transportation sector and grid interactive electricity generation. These shipments by end use are distributed across various market sectors as described in the following section.

Table 17. Photovoltaic Module and Cell Shipments by End Use, 1989

End Use	Amount Shipped (peak kilowatts)	Percent of Total
Health	5	0.04
Water Pumping	711	5.5
Transportation	1,196	9.3
Communication	2,590	20.2
Consumer Goods	2,788	21.7
Electric Generation		
Grid Interactive	1,251	9.8
Other Remote	2,620	20.4
Cells to Original Equipment Manufactured	1,595	12.4
Other	69	0.54
Total	12,825	100.0

Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, "Annual Photovoltaic Module/Cell Manufacturers Survey," Form CE-63B, 1987-1989.

Table 18. Photovoltaic Module and Cell Shipments by Market Sector, 1989

Market Sector	Amount Shipped (peak kilowatts)	Percent of Total
Government	1,077	8.4
Residential	1,439	11.2
Commercial	3,850	30.0
Industrial	3,993	31.1
Utility	785	6.1
Transportation	1,130	8.8
Other	551	4.3
Total	12,825	100.0

Sources: Energy Information Administration, "Annual Photovoltaic Module/Cell Manufacturers Survey," Form EIA-63, 1982-1984; Form CE-63B, 1985-1989.

Shipments by Market Sector

The market sector category includes government, residential, commercial, industrial, utility, and transportation. Shipments to the industrial sector (31 percent) and the commercial sector (30 percent) were the largest market sector categories (Table 18).

Exports and Imports

Photovoltaic module and cell manufacturers exported 7,363 kilowatts of PV modules and cells in 1989, compared with 1988 exports of 5,358 kilowatts of modules only. Exports in 1989 represented more than 58 percent of all shipments. This is similar to 1988 when exports represented nearly 55 percent of shipments. Of the 7,363 kilowatts exported in 1989, modules comprised 5,468 kilowatts (74 percent) and cells comprised 1,895 kilowatts (16 percent). The predominant type of PV module and cell exported were single-crystal silicon devices. Cast-silicon modules and cells were the second most popular, followed by amorphous silicon.

In 1989, four companies imported 826 kilowatts of PV modules and cells. Cast-silicon and single crystal silicon were the predominant module and cell types imported, followed by a negligible amount of amorphous silicon. The countries of origin of imported modules were Japan, India, Taiwan, Norway, Australia, and Singapore.

Technology Status and Photovoltaic Industry Plans

Table 19 presents the number of companies planning to introduce new PV-related products in 1990, as indicated by data from the 1989 survey. Table 20 provides the number of manufacturers involved in various PV-related activities during 1988 and 1989.

Table 19. Number of Photovoltaic Module Manufacturers Expecting to Introduce New Photovoltaic-Related Products Within Year of Survey

Type of Product	Number of Manufacturers	
	Survey Year 1989	Survey Year 1988
Single-Crystal Silicon Modules	3	3
Cast Silicon Modules	3	3
Ribbon Silicon Modules	0	1
Amorphous Silicon Modules	5	4
Other (Flat Plate)	2	2
Other (Concentrator)	1	2
Nonmodule System Components	2	3
Other (Thin Film)	1	–

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1987-1989.

Table 20. Number of Photovoltaic Module Manufacturers Involved in Photovoltaic-Related Activities, 1989 and 1988

Type of Activity	Number of Manufacturers	
	1989	1988
Cell Manufacturing	11	–
Module or System Design	16	12
Prototype Module Development	13	11
Prototype Systems Development	12	8
Wholesale Distribution of Modules	10	8
Retail Distribution of Modules	6	9
Installation	7	5
Nonmodule System Component Manufacture	6	4
Other	4	3

Source: Energy Information Administration, "Annual Photovoltaic Module/Cell Manufacturers Survey," Form CE-63B, 1987-1989.

Appendix A

Survey Methodology

Appendix A

Survey Methodology

Survey Procedure

The solar thermal collector (Form CE-63A) and photovoltaic module or cell (Form CE-63B) manufacturer survey forms cover a 12-month period, from January through December of each calendar year. The 1989 survey was sent out via certified mail in May 1990. (Appendix B gives a copy of the survey forms.)

Questions in the survey are designed to elicit data on company shipments, manufacturing, importing, exporting, and related activities. Care has been taken to establish the survey frame accurately. However, because the solar collector manufacturing industry is subject to sporadic entry and exit of manufacturers, the frame of this survey may exclude some of the manufacturers who entered the industry after 1984--particularly in 1985, a year in which the survey was not conducted.

Manufacturers of solar thermal collectors were requested to report their annual shipments in terms of square feet of collectors shipped whether manufactured or imported. Surveyed companies were also requested to indicate prototype development, note other related activities in which they were engaged, provide information concerning market sector and end-use breakdowns, as well as information on company size. All appropriate data were disaggregated by type of solar collector. Manufacturers of photovoltaic modules were asked to provide similar data indicating production in terms of electrical capacity expressed in peak kilowatts.

Follow-up procedures were carried out to reduce the nonresponse rate and possible resulting bias. Follow-up procedures consisted of (1) re-sending surveys to companies with new addresses, (2) reminder calls to all companies that did not return completed survey forms within the 1-month period specified in the cover letter, and (3) additional calls to companies that did not respond within a few weeks of the first round of calls. During the second round of calls, data were taken over the telephone whenever possible. Data received over the phone were entered on a blank survey form that was then returned to the company for verification and appropriate signatures.

Responses to the surveys were first edited manually to verify the accuracy of the reporting and to ensure reliability of the data. Selected individual company responses were also compared with the data reported in previous surveys. Wherever manual editing procedures indicated discrepancies or omissions, telephone calls were made to confirm or clarify the data. Data from manually edited forms were then entered into a computer and edited a second time via an automated procedure.

Survey Format

In 1985, the solar manufacturers questionnaire was modified to give more useful information than the previous survey form (EIA-63). The modifications included devising two separate forms: one for solar thermal collector manufacturers (Form CE-63A), and the other for photovoltaic module manufacturers (Form CE-63B). The modifications affecting both forms and each form individually are outlined below:

Modifications affecting both survey forms:

- Information on the respondent's company type (partnership, corporation, or single proprietorship) was not included in the new questionnaires.
- Market sector and end-use categories were redefined under more appropriate headings in 1985. (Note: because of these altered categories, direct comparisons between 1984 and prior years' data and subsequent years' data are difficult to make.)
- The term "manufacture" was defined to account for outbound shipments only, in contrast to actual manufacture, importation, or sales.

Modifications affecting the "Annual Solar Thermal Collector Manufacturers Survey" (Form CE-63A):

- Information on metallic and nonmetallic low-temperature collectors was combined into one category.
- Information on medium-temperature liquid collectors was divided into three separate categories:

Table A1. Number of Reporting Companies and Shipments, 1984-1986

Item	1984	1985[a]	1986
Number of Firms	224	116	97
Shipments (million square feet)	16.4	11.1	4.9

[a] Incomplete data.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form EIA-63, 1984; Form CE-63A, 1985 and 1986.

thermosiphon, flat-plate (pumped), and integral collector storage (ICS).

Modifications affecting the "Annual Photovoltaic Module Manufacturers Survey" (Form CE-63B):

- Questions were included regarding exports of modules versus cells.
- Questions were included regarding country of destination for exports of modules and cells.

Survey Limitations, 1985

During 1986 the solar collector manufacturing industry experienced a substantial slowdown in shipments as a result of the expiration of the solar tax credit at the end of 1985 and the reduction in energy prices. Reported shipments declined from 16.4 million square feet in 1984 to 4.9 million square feet in 1986. Many of the 1986 shipments probably occurred during the first quarter, as customers took delivery of materials purchased in late 1985 when solar tax credits were still available. Table A1 presents the number of companies reporting and their reported shipments for the years 1984 through 1986.

Although reported shipments for 1985 were only 68 percent of those reported in 1984, it is likely that actual shipments were higher in 1985, which was believed to be a banner year because the energy tax credit expired at the end of the year. The number of firms reporting and, therefore, the reported shipments may have been low because many of the firms had gone out of business, and could not be located to collect the 1985 data when the data collection forms were mailed out more than 1 year later in early 1987. Table A2 presents the shipments for only the 80 firms that were in business all 3 years.

For the 80 firms that were in business all 3 of the years, shipments increased 14 percent in 1985 but decreased by 54 percent in 1986. Although it is not conclusive, it is an indication that if all the shipments for all firms in business in 1985 were reported, there may have been a substantial increase from 1984 to 1985.

Changes to the 1989 Survey

Forms CE-63A and B were modified in 1989 and recleared by the Office of Management and Budget. The major changes are summarized below.

Form CE-63A

- Questions on **high temperature collectors** (parabolic disk or trough) were added to Section 4.0 for the first time.
- Three questions on the shipment and value of **complete systems** were added.

Form CE-63B

- The collection of **cell** data was added in addition to modules.
- The end-use and market sector categories were broadened.
- Three questions on the shipment and value of **complete systems** were added.

Table A2. Shipments for Companies Reporting in All Years, 1984-1986

Item	1984	1985[a]	1986
Number of Firms	80	80	80
Shipments (million square feet)	8.7	9.9	4.6

[a] Incomplete data.
Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form EIA-63, 1984; Form CE-63A, 1985 and 1986.

Survey Response Rates

Manufacturers of Solar Thermal Collectors

The status of solar thermal collector manufacturers who were mailed survey forms for the 1988 survey is shown in Table A3. The 1989 survey responses to questionnaires sent to 76 potential solar collector manufacturers resulted in the following categories:

- Active companies: 44 questionnaires were returned by companies with shipments during this survey period.
- Inactive: 20 companies on the mailing list had no shipments in 1989 but were kept on the list because they may have shipments in future years.
- Out of business: 12 of the listed manufacturers were out of the solar manufacturing business during 1989 and have no plans to reenter the business in a future year.

Manufacturers of Photovoltaic Modules

The status of the photovoltaic module manufacturers who were mailed survey forms for the 1989 survey is also shown in Table A3.

Table A3. Status of Solar Thermal Collector and Photovoltaic Module Manufacturers, 1989 Survey

Status	Number of Companies	
	Solar Thermal Collector	Photovoltaic Module and Cell
Active	44	17
Inactive	20	3
Out of Business	12	1
Total	76	21

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1989 and "Annual Photovoltaic Module/Cell Manufacturers Survey," Form CE-63B, 1989.

Appendix B

Survey Questionnaires and Instructions

CE-63A
(12/__)

OMB No.: 1905-0172
Exp. Date: 12/31/92

Form CE-63A

U.S. DEPARTMENT OF ENERGY

Energy Information Administration

ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY

This report is mandatory under FEA Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91). Failure to comply may result in criminal fines, civil penalties and other sanctions as provided by law. For the provisions concerning the confidentiality of information submitted on this form, see Part VI of the instructions. *Public reporting burden for this collection of information is estimated to average 3 hours per response* including the time reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, EI-73, Mail Station 1H-023 Forrestal, 1000 Independence Ave., S.W., Washington, D.C. 20585, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

The reporting period for this survey is calendar year 19__

For definitions and instructions, please refer to the General Information and Instructions section of this form.

1.0 IDENTIFICATION DATA

1.1 Respondent Identification

Complete (a) through (d) only if label is incorrect:

(a) Company Name: _____

(b) Street Address: _____

(c) City: _____

(d) State and Zip Code: _____

1.2 Provide the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission.

(a) Name: _____ (c) Telephone: _____ (Area Code) _____ (Number)

(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "definition" section for key words.)

2.1 During the current reporting period, did your company:

	(Mark as appropriate)	
(a) Manufacture and ship solar energy collectors?	☐ Yes	☐ No
(b) Cease manufacturing but continue to ship solar energy collectors?	☐ Yes	☐ No
(c) Import and ship solar energy collectors?	☐ Yes	☐ No
(d) Manufacture and export solar energy collectors?	☐ Yes	☐ No

2.2 If you answered "No" to *all* parts of question 2.1, do you plan to manufacture, import, export, and ship solar collectors in the future? If yes, when? _____ (year) ☐ Yes ☐ No

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 8.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the solar-related activities in which your company was engaged in during this reporting period. Mark all that apply to your solar activities only.

(a) ☐ Collector or system design
(b) ☐ Prototype collector development
(c) ☐ Prototype systems development
(d) ☐ Wholesale distribution
(e) ☐ Retail distribution
(f) ☐ Installation
(g) ☐ Manufacture of system-components other than those used for collector assembly
(h) ☐ Other (describe): _____

_____

3.2 If you are expecting to introduce a new solar-related product in the next calendar year, please check the appropriate box.

(a) ☐ Low-Temperature Collector
(b) ☐ Medium-Temperature Collector
(c) ☐ High-Temperature Collector
(d) ☐ Noncollector Solar System Components
(e) ☐ Other (describe): _____

_____

3.3 Please enter the number of full-time-equivalent employees in your company that were engaged in solar-related activities during this reporting period. (For clarification of "full-time-equivalent," see the instructions.) _____

3.4 What percentage of your company's total sales volume do solar-related activities compose?

(a) ☐ 90 - 100%
(b) ☐ 50 - 89%
(c) ☐ 10 - 49%
(d) ☐ Less than 10%

Company Name:_____ Reporting Period (Calendar year 19__)

4.0 SOLAR THERMAL COLLECTOR–DATA. ***For each type of collector manufactured or imported, and shipped, enter the data for this reporting period.***

ITEM	COLLECTOR TYPE								
	Low Temperature	Medium Temperature					High Temperature	Other (specify)	Total
	(Liquid and Air)	Air	Liquid						
	Metallic and Nonmetallic (a)	All Medium Temperature (b)	Integral Collector Storage/ Thermosiphon (c)	Flat Plate (pumped) (d)	Concentrator (e)	Evacuated Tube (f)	Parabolic Dish/ Trough (g)	(h)	(i)
4.1 Total Collector Shipments (square feet)									
4.2 Total Value of Collector Shipments in 4.1 (dollars)									
4.3 Market Sector (square feet)									
(1) Residential									
(2) Commercial									
(3) Industrial									
(4) Utility									
(5) Other (describe)									
Total, market sector*									
4.4 End Use (square feet)									
(1) Pool heating									
(2) Hot water									
(3) Space heating									
(4) Combined space and water heating									
(5) Space cooling									
(6) Processing heating									
(7) Electricity generation									
(8) Other (describe)									
Total, end use*									
4.5 Imports (square feet of total in 4.1)									
4.6 Exports (square feet of total in 4.1)									
4.7 List Country(ies) of Origin of Imports in 4.5									
4.8 List Country(ies) of Destination for Exports in 4.6									

* Should equal to shipments reported in Question 4.1.

4.9 Enter the square footage of collectors from question 4.1(i) that were shipped to:

	Square Feet (From 4.1(i))
(a) Exporters	_____
(b) Wholesale Distributors	_____
(c) Retail Distributors	_____
(d) Installers	_____
(e) End-Users	_____
(f) Other (describe)	_____
TOTAL	_____

5.0 SYSTEMS DATA

5.1 Of the total collector shipments reported in question 4.1(i), how many complete systems were shipped _____ (number of systems)?

5.2 Of the collector shipments reported in question 4.1(i), enter the square footage that was sold as part of complete systems _____ (square feet).

5.3 What was the total value of complete systems reported in question 5.1 _____ (dollars)?

6.0 GEOGRAPHIC DATA

6.1 Report the percentage (%) of your company's collectors manufactured in the state listed below under Code 01-53. If some collectors were imported from another country, please indicate the percentage under Code 00.

State Code	*% Collectors Imported or Manufactured in the State*	*State Code*	*% Collectors Imported or Manufactured in the State*	*State Code*	*% Collectors Imported or Manufactured in the State*
00	☐ Imported _____	18	☐ Kentucky _____	36	☐ Ohio _____
01	☐ Alaska _____	19	☐ Louisiana _____	37	☐ Oklahoma _____
02	☐ Alabama _____	20	☐ Maine _____	38	☐ Oregon _____
03	☐ Arizona _____	21	☐ Maryland _____	39	☐ Pennsylvania _____
04	☐ Arkansas _____	22	☐ Massachusetts _____	40	☐ Puerto Rico _____
05	☐ California _____	23	☐ Michigan _____	41	☐ Rhode Island _____
06	☐ Colorado _____	24	☐ Minnesota _____	42	☐ South Carolina _____
07	☐ Connecticut _____	25	☐ Mississippi _____	43	☐ South Dakota _____
08	☐ Delaware _____	26	☐ Missouri _____	44	☐ Tennessee _____
09	☐ D.C. _____	27	☐ Montana _____	45	☐ Texas _____
10	☐ Florida _____	28	☐ Nebraska _____	46	☐ Utah _____
11	☐ Georgia _____	29	☐ Nevada _____	47	☐ Vermont _____
12	☐ Hawaii _____	30	☐ New Hampshire _____	48	☐ Virgin Islands _____
13	☐ Idaho _____	31	☐ New Jersey _____	49	☐ Virginia _____
14	☐ Illinois _____	32	☐ New Mexico _____	50	☐ Washington _____
15	☐ Indiana _____	33	☐ New York _____	51	☐ West Virginia _____
16	☐ Iowa _____	34	☐ North Carolina _____	52	☐ Wisconsin _____
17	☐ Kansas _____	35	☐ North Dakota _____	53	☐ Wyoming _____

Total Percentage _____% (should amount to 100%)

6.2 Report the percentage (%) of your company's collectors likely to have been shipped to the state listed below under Code 01-53, this includes shipments to the state of manufacture. If some collectors were exported, please indicate the percentage under Code 00.

State Code	% Collectors Exported or Shipped to the State	State Code	% Collectors Exported or Shipped to the State	State Code	% Collectors Exported or Shipped to the State
00	☐ Exported _____	18	☐ Kentucky _____	36	☐ Ohio _____
01	☐ Alaska _____	19	☐ Louisiana _____	37	☐ Oklahoma _____
02	☐ Alabama _____	20	☐ Maine _____	38	☐ Oregon _____
03	☐ Arizona _____	21	☐ Maryland _____	39	☐ Pennsylvania _____
04	☐ Arkansas _____	22	☐ Massachusetts _____	40	☐ Puerto Rico _____
05	☐ California _____	23	☐ Michigan _____	41	☐ Rhode Island _____
06	☐ Colorado _____	24	☐ Minnesota _____	42	☐ South Carolina _____
07	☐ Connecticut _____	25	☐ Mississippi _____	43	☐ South Dakota _____
08	☐ Delaware _____	26	☐ Missouri _____	44	☐ Tennessee _____
09	☐ D.C. _____	27	☐ Montana _____	45	☐ Texas _____
10	☐ Florida _____	28	☐ Nebraska _____	46	☐ Utah _____
11	☐ Georgia _____	29	☐ Nevada _____	47	☐ Vermont _____
12	☐ Hawaii _____	30	☐ New Hampshire _____	48	☐ Virgin Islands _____
13	☐ Idaho _____	31	☐ New Jersey _____	49	☐ Virginia _____
14	☐ Illinois _____	32	☐ New Mexico _____	50	☐ Washington _____
15	☐ Indiana _____	33	☐ New York _____	51	☐ West Virginia _____
16	☐ Iowa _____	34	☐ North Carolina _____	52	☐ Wisconsin _____
17	☐ Kansas _____	35	☐ North Dakota _____	53	☐ Wyoming _____

Total Percentage _____% (should amount to 100%)

7.0 PUBLICATION DATA

7.1 Do you want the name and address of your company to appear in the appendix of the next Solar Collector Manufacturing Activity report? ☐ Yes ☐ No

7.2 Do you want to receive a copy of the next Solar Collector Manufacturing Activity report? ☐ Yes ☐ No

8.0 CERTIFICATION

I certify that the information contained and appended is true and accurate to the best of my knowledge.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here: _____

_____

_____

_____

OMB No.: 1905-0172
Exp. Date: 12/31/92

INSTRUCTIONS FOR FORM CE-63A, ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY GENERAL INFORMATION AND INSTRUCTIONS

I. Purpose

Form CE-63A is designed to provide the data necessary for the Energy Information Administration (EIA) in the Department of Energy (DOE) to carry out its responsibilities for tracking certain volumetric movements in the solar collector manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity* will contain the results of this survey.

II. Who Should Respond to This Survey

Form CE-63A is to be submitted by (1) all companies that manufactured and shipped (including exporting) solar thermal collectors and (2) companies that imported solar thermal collectors during the reporting period. If you are completing this survey form for the first time, but were active in the industry during the previous period, please photocopy the entire form and provide us with last year's data also.

III. Where to Submit Completed Forms

Companies should return completed CE-63A forms to:

Energy Information Administration, EI-531
Mail Station: BG-094-Forrestal
U.S. Department of Energy
Attn: CE-63 A
Washington, D.C. 20585

Requests for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at *(202) 254-5568 or (202) 254-5562.*

IV. When to Submit Completed Forms

Completed CE-63A forms are due on the date specified in the cover letter. The reporting period is from January 1 through December 31.

V. Sanctions

This report is mandatory and is being required pursuant to the authority granted to DOE by the Federal Energy Administration Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91).

VI. Provisions Regarding Confidentiality

The information contained on this form will be kept confidential to the extent that it satisfies the criteria for exemption in the Freedom on Information Act (FOIA), the DOE regulations implementing the FOIA, and the Trade Secrets Act, 18 U.S.C. Section 1905.

Upon receipt of a request for this information under the FOIA, the DOE shall, in accordance with the procedures and criteria provided in 10 C.F.R. section 1004.11, make a final determination whether the information is exempt from disclosure. To assist in this determination, respondents should demonstrate to the DOE that, for example, their information contains trade secrets or commercial or financial information which if released would likely cause substantial harm to their company's competitive position. A letter accompanying the submission that explains (on an element-by-element basis) the reasons why the information would be likely to cause the respondent substantial competitive harm if released to the public would aid in this determination. A new justification does not need to be provided each time information is submitted on the form, if the company has previously submitted a justification for that information and the justification has not changed.

Except as otherwise provided by law, the information may be made available in response to an order of a Court of competent jurisdiction, or, upon request, to other components of the Department of Energy, to any Committee of Congress, the General Accounting Office, or other congressional agencies authorized by law to receive such information. Detailed provisions of the restrictions on the disclosure of this information can be found in the Policy on the Disclosure of Individually Identifiable Energy Information in the Possession of the Energy Information Administration (45 Federal Register Section 59812 (1980)).

DEFINITIONS

1. Air Collector – A medium-temperature collector used predominantly in space heating, utilizing pumped air as the heat-transfer medium.

2. Concentrator – A reflective or refractive solar thermal collector that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.

3. Evacuated Tube – In a solar thermal collector, an absorber tube, contained in an evacuated glass cylinder, through which collector fluid flows.

4. Exports – Solar collectors only, manufactured in the United States and shipped to another country.

5. Flat Plate (Pumped) – Medium-temperature liquid collectors, which typically utilize a metal frame, glazing, absorbers (usually metal), and insulation, and use pumped liquid as the heat transfer medium; predominantly used in water heating applications.

6. High-Temperature Collectors – Collectors which operate above 180° F.

7. Imports – Solar collectors only, manufactured outside of the United States and shipped into the United States.

8. Integral Collector Storage (ICS) – Collectors in which solar radiation is absorbed directly by the storage medium.

9. Low-Temperature Collectors – Metallic or nonmetallic collectors that generally operate at temperatures below 110°F and use pumped liquid or air as the heat transfer medium. They usually contain no glazing and no insulation, and they are often made of plastic or rubber, although some are made of metal.

10. Medium-Temperature Collectors – Collectors that generally operate in the temperature range of 140°F to 180°F but can also operate at a temperature as low as 110°F. The collectors are typically made of a metal frame, metal absorption panels with integral flow channels or attached tubing (liquid collectors) or with integral ducting (air collectors), and glazing and insulation on the sides and back.

11. Metallic – The metallic material composition of the collector's absorber system.

12. Parabolic Dish – High temperature (180°+) concentrators, generally circular in shape, with two axis tracking.

13. Trough – High temperature (180°+) concentrator with one axis tracking.

SPECIFIC INSTRUCTIONS

Specific instructions for most items are provided below.

Item	Instruction
1.1 (a)-(d)	Make corrections to the company name or address in the space provided.
1.2 (a)-(c)	Enter the name, title, and telephone number of an individual in the reporting company whom may be contacted for additional information regarding this submission.
2.0	Mark as appropriate in 2.1(a) through 2.1(d) the manufacturing activity conducted by your company during the current reporting period.
3.1 (a)-(h)	Report only on activities that are solar related.
3.2 (a)-(e)	A new solar-related product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	"Full-time-equalivent" is defined as salaried employee time of at least 1,800 hours per year. Combined time of part-time solar-related employees meets the definition. Round to the nearest digit.
3.4	"Solar-related activities" includes all activities listed in question 3.1.
4.1	Enter the square footage (not the number of collectors), in whole numbers (i.e., no decimals), of solar collectors shipped for final consumption or to another organization for resale (including exports and imports) in the appropriate collector type column. Total (column i) should be the total square feet of all collector types in that row.
4.2	The value reported should be total value received for the collectors only, at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar.
4.3	For each appropriate sector, enter the square footage of collector shipments, by collector type, as precisely as possible. For market-sector categories in question 4.3: Part (1) *Residential* – Solar applications related to any building used for residential occupancy that has a system for heating or cooling, or both. Part (2) *Commercial* – Solar applications for use in businesses where services (rather than products) are provided, such as wholesale and retail trade or health and educational services. Part (3) *Industrial* – Solar applications for use in businesses where products (rather than services) are provided, such as the manufacture and processing of goods and basic materials. Part (4) *Utility* – Shipments of solar collectors to utilities for use in power generation or for experimental applications. (Includes gas and electric utilities.) Part (5) Self-explanatory. Part (6) Total should be the same total square footage of all collector types as was entered in 4.1.
4.4	For each end use, enter the square footage of collector shipments, by collector type, as precisely as possible. For each end-use category in question 4.4: Part (1) through Part (4) Self-explanatory. Part (5) If collectors are used for space cooling, or for space cooling in combination with water and/or space heating, enter the total square footage.

Item	Instruction
4.5	Enter the square footage by collector type. This represents the portion of total collector shipments entered in 4.1 that were imported and shipped by your firm.
4.6	Enter the square footage by collector type. This represents the portion of total collector shipments entered in 4.1 that were manufactured for export and shipped (sold) to another country.
4.7	Enter the country(ies) from which solar collectors reported in question 4.5 were imported.
4.8	Enter the country(ies) to which solar collectors reported in question 4.6 were exported.
4.9	Of the collectors reported in question 4.1(i), report in square feet, the recipient of solar thermal collectors immediately following manufacturing or warehousing. If recipients overlap (for example, the recipient is both a wholesale distributor and an installer) report the recipient in the higher category (i.e., a is higher than b, b is higher than c, etc.)
5.1	Enter number of complete systems shipped from the total in question 4.1(i).
5.2	Of the collectors reported in 4.1(i), enter the square footage that was sold as complete systems. (Complete system is defined as a unit with all the necessary functional components, except for installation materials. These include thermosiphon systems, integral collector storage systems, packaged systems, or system kits.)
5.3	The value reported should be the total value received for the complete systems, at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. (It should include the value of the associated collectors.) Do not include excise taxes, freight or transportation charges, or installation charges. Report values to the nearest dollar.
6.1	Please identify only the State of final assembly of the collector. Please be certain to provide total percentage calculations.
6.2	Refers to collector shipments only. Indicate the last State of destination of which you are aware.
7.1	Mark as appropriate.
7.2	Mark as appropriate.
8.0	Self-explanatory.

CE-63B
(12/__)

OMBNo.: 1905-0172
Exp. Date: 12/31/92

Form CE-63B

U.S. DEPARTMENT OF ENERGY

Energy Information Administration

ANNUAL PHOTOVOLTAIC MODULE/CELL MANUFACTURERS SURVEY

This report is mandatory under FEA Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91). Failure to comply may result in criminal fines, civil penalties and other sanctions as provided by law. For the provisions concerning the confidentiality of information submitted on this form, see Part VI of the instructions. *Public reporting burden for this collection of information is estimated to average 3 hours per response* including the time reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, EI-73, Mail Station 1H-023 Forrestal, 1000 Independence Ave., S.W., Washington, D.C. 20585, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

The reporting period for this survey is calendar year 19__

For definitions and instructions, please refer to the General Information and Instructions section of this form.

1.0 IDENTIFICATION DATA

1.1 Respondent Identification

Complete (a) through (d) only if label is incorrect:

(a) Company Name: _____

(b) Street Address: _____

(c) City: _____

(d) State and Zip Code: _____

1.2 Provide the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission.

(a) Name: _____ (c) Telephone: _____ _____
Area Code Number

(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "definition" section for key words.)

2.1 During the current reporting period, did your company:

	(Mark as appropriate)	
(a) Manufacture and ship photovoltaic modules/cells?	☐ Yes	☐ No
(b) Cease manufacturing but continue to ship photovoltaic modules/cells?	☐ Yes	☐ No
(c) Import and ship photovoltaic modules/cells?	☐ Yes	☐ No
(d) Manufacture and export photovoltaic modules/cells?	☐ Yes	☐ No

2.2 If you answered "No" to *all* parts of question 2.1, do you plan to manufacture, import, export, and ship photovoltaic modules/cells in the future? If yes, when? _____ (year) ☐ Yes ☐ No

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 7.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the photovoltaic-related activities in which your company was engaged in during this reporting period. Mark all that apply to your photovoltaic activities only.

(a) ☐ Cell manufacturing
(b) ☐ Module or system design
(c) ☐ Prototype module development
(d) ☐ Prototype systems development
(e) ☐ Wholesale distribution of modules
(f) ☐ Retail distribution of modules
(g) ☐ Installation
(h) ☐ Manufacture of system-components other than those used for module assembly
(i) ☐ Other (describe): _____

_____

3.2 If you are expecting to introduce new photovoltaic-related products in the next calendar year, please check the appropriate box(es).

(a) ☐ Single-crystal silicon modules
(b) ☐ Cast silicon modules
(c) ☐ Ribbon silicon modules
(d) ☐ Amorphous silicon modules
(e) ☐ Other thin film
(f) ☐ Other (flat plate) – specify: _____
(g) ☐ Other (concentrator) – specify: _____
(h) ☐ Nonmodule system components – specify: _____

3.3 Please enter the number of full-time-equivalent employees in your company that were engaged in photovoltaic-related activities during this reporting period. (For clarification of "full-time-equivalent," see the instructions.) _____

Company Name: _____ Reporting Period (Calendar year 19__)

4.0 PHOTOVOLTAIC MODULES AND CELL SHIPMENT DATA. ***For each type of module/cell manufactured or imported, and shipped, enter the data for this reporting period.***

ITEM	MODULE/CELL TYPE							
	Crystalline Silicon			Thin Film		Concentrator	Other	Total
	Single-Crystal (Czochralsky) (a)	Cast (b)	Ribbon (c)	Amorphous Silicon (d)	Other (e)	(f)	(g)	(h)
4.1 Quantity of Shipments (in kw)								
(1) Total net module shipments								
(2) Total net cell shipments								
Total quantity of shipments								
4.2 Value of Shipments (dollars)								
(1) Value of module shipments								
(2) Value of cell shipments								
Total value of shipments								
4.3 End Use (in kw)								
(1) Health								
(2) Water pumping								
(3) Transportation								
(4) Communication								
(5) Consumer goods (modules)								
(6) Electric generation								
(a) Grid interactive								
(b) Other remote (stand alone)								
(7) Cells to original equipment manufacturer (non-PV)								
(8) Other uses: Specify _____								
Total end use*								
4.4 Market Sector								
(1) Government								
(2) Residential								
(3) Commercial								
(4) Industrial								
(5) Utility								
(6) Transportation								
(7) Other sectors: Specify _____								
Total market sector*								
4.5 Imports (in kw)								
(1) Modules								
(2) Cells								
Total imports								
4.6 Exports (in kw)								
(1) Modules								
(2) Cells								
Total exports								
4.7 List Country(ies) of Origin of Imports in Question 4.5								
4.8 List Country(ies) of Destination for Exports in Question 4.6								

* Should equal to shipments reported in Question 4.1.

4.9 Enter the quantity (in kilowatts) of modules and cells reported in 4.1(1)(h) and 4.1(2)(h) that were shipped to:

	Modules (From 4.1(1)(h))	Cells (From 4.1(2)(h))
(a) Exporters	_____	_____
(b) Module Manufacturers	_____	_____
(c) Wholesale Distributors	_____	_____
(d) Retail Distributors	_____	_____
(e) Installers	_____	_____
(f) End-Users	_____	_____
(g) Other (describe)	_____	_____
TOTAL	_____	_____

5.0 TOTAL SHIPMENT DATA

5.1 Of the total modules shipped in 4.1(1)(h), how many complete systems were shipped _____ (number of systems)?

5.2 Of the modules shipped in 4.1(1)(h), enter the peak kilowatts that were sold as part of complete systems _____ (kilowatts).

5.3 What was the value of complete systems shipped in question 5.1 _____ (dollars)?

6.0 PUBLICATION DATA

6.1 Do you want the name and address of your company to appear in the appendix of the next Solar Collector Manufacturing Activity report? ☐ Yes ☐ No

Do you want to receive a copy of the next Solar Collector Manufacturing Activity report? ☐ Yes ☐ No

7.0 CERTIFICATION

I certify that the information contained and appended is true and accurate to the best of my knowledge.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here: _____

_____

_____

_____

OMB No.: 1905-0172
Exp. Date: 12/31/92

INSTRUCTIONS FOR FORM CE-63B, ANNUAL PHOTOVOLTAIC MODULE MANUFACTURERS SURVEY GENERAL INFORMATION AND INSTRUCTIONS

I. Purpose

Form CE-63B is designed to provide the data necessary for the Energy Information Administration (EIA) in the Department of Energy (DOE) to carry out its responsibilities for tracking certain volumetric movements in the photovoltaic module manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity* will contain the results of this survey.

II. Who Should Respond to This Survey

Form CE-63B is to be submitted by (1) all companies that manufactured and shipped (including exporting) photovoltaic modules and (2) companies that imported photovoltaic modules during the reporting period. If you are completing this survey form for the first time, but were active in the industry during the previous period, please photocopy the entire form and provide us with last year's data also.

III. Where to Submit Completed Forms

Companies should return completed CE-63B forms to:

Energy Information Administration, EI-531
Mail Station: BG-094-Forrestal
U.S. Department of Energy
Attn: CE-63 B
Washington, D.C. 20585

Requests for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at *(202) 254-5568 or (202) 254-5562.*

IV. When to Submit Completed Forms

Completed CE-63B forms are due on the date specified in the cover letter. The reporting period is from January 1 through December 31.

V. Sanctions

This report is mandatory and is being required pursuant to the authority granted to DOE by the Federal Energy Administration Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91).

VI. Provisions Regarding Confidentiality

The information contained on this form will be kept confidential to the extent that it satisfies the criteria for exemption in the Freedom on Information Act (FOIA), the DOE regulations implementing the FOIA, and the Trade Secrets Act, 18 U.S.C. Section 1905.

Upon receipt of a request for this information under the FOIA, the DOE shall, in accordance with the procedures and criteria provided in 10 C.F.R. section 1004.11, make a final determination whether the information is exempt from disclosure. To assist in this determination, respondents should demonstrate to the DOE that, for example, their information contains trade secrets or commercial or financial information which if released would likely cause substantial harm to their company's competitive position. A letter accompanying the submission that explains (on an element-by-element basis) the reasons why the information would be likely to cause the respondent substantial competitive harm if released to the public would aid in this determination. A new justification does not need to be provided each time information is submitted on the form, if the company has previously submitted a justification for that information and the justification has not changed.

Except as otherwise provided by law, the information may be made available in response to an order of a Court of competent jurisdiction, or, upon request, to other components of the Department of Energy, to any Committee of Congress, the General Accounting Office, or other congressional agencies authorized by law to receive such information. Detailed provisions of the restrictions on the disclosure of this information can be found in the Policy on the Disclosure of Individually Identifiable Energy Information in the Possession of the Energy Information Administration (45 Federal Register Section 59812 (1980)).

DEFINITIONS

1. Amorphous Silicon – Thin layers of noncrystalline material, primarily silicon based, deposited onto a metallic or nonmetallic surface, that compose a module.

2. Cast Silicon – Polycrystalline silicon cells, derived by various techniques, that compose a module. Cells referred to as semicrystalline are included.

3. Cells – Refers to the un-encapsulated semiconductor components of the module which convert the solar energy to electricity. In questions 4.1 through 4.5 report only cells that are shipped to end-users or non-photovoltaic original equipment manufacturers. Cells which are shipped to other photovoltaic module manufacturers should not be reported. However, in question 4.6 report all cell exports, including those that are shipped to foreign photovoltaic module manufacturers.

4. Cells to OEM (Non-PV) – Cells shipped to non-photovoltaic original equipment manufacturers such as boat manufacturers, car manufacturers, etc.

5. Commercial – Photovoltaic modules or cells employed to produce power for commercial establishments, such as office buildings, private hospitals, private schools, retail establishments, etc. (Publicly owned schools, hospitals, and other institutions should be listed under government.) Excludes other market sectors specified in question 4.4(1) through (7).

6. Communication – Photovoltaic modules/cells employed to power fixed base telecommunications equipment, such as mountain top repeater stations. Modules/cells issued for space applications are not to be included in this survey.

7. Concentrator – Reflective or refractive photovoltaic module/cell that focuses solar rays onto an area smaller than the reflective or refractive surface, thus increasing the intensity of the solar rays at the point of focus. (Report on module kW not cell kW.)

8. Consumer Goods – Photovoltaic modules/cells used to power consumer goods such as portable radios, toys, watches, calculators, small battery chargers, etc. (Please specify on the bases of stabilized full sun rating.)

9. Electric Generation – Grid interactive and remote or stand alone power generation for general uses, including those for grid distribution and general remote uses like: residential power and power for mobile homes.

10. Government – Photovoltaic modules or cells employed to produce power for any branch of the Federal, state, and local government (including the military and including such uses as research, development, and demonstration projects). This definition excludes foreign governments, which should be reported in question 4.3(7) Other Sources.

11. Exports – Photovoltaic modules and cells manufactured in the United States and shipped to another country.

12. Health – Photovoltaic modules/cells used in health/medical applications such as those used for powering medical refrigerators, medical equipment and for water purifications.

13. Imports – Photovoltaic modules/cells manufactured outside of the United States and shipped into the United States from another country.

14. Industrial – Photovoltaic modules employed to produce power for industrial applications. Includes both grid and non-grid connected systems. Excludes other market sectors specified in questions 4.4(1) through (7).

15. Modules – Photovoltaic cells or an assembly of cells into panels (modules) intended for and shipped for final consumption, or to another organization for resale. When exported, incomplete modules and un-encapsulated cells are also included. Modules used for space applications are not to be included in this survey.

16. Net Cell Shipments – Represents the difference between cell (as defined above) shipments and cell purchases. Incomplete cells, such as wafers, should not be reported. Cell shipments to U.S. based photovoltaic module manufacturers should not be reported. (In question 4.5(2) report all photovoltaic cells that were imported.)

17. Net Module Shipments – Represents the difference between module (as defined above) shipments and module purchases. When exported, incomplete modules and un-encapsulated cells are also included.

18. Residential – Photovoltaic modules that are used in distributed, grid connected photovoltaic systems to provide power for residential applications.

19. Ribbon Silicon – Single-crystal silicon derived by means of fabricating processes that produce sheets or ribbons of single-crystal silicon. These processes include: edge-defined film-fed growth (EFG), dendritic web growth, and ribbon-to-ribbon growth (RTR).

20. Silicon – A semiconductor material made from silica, purified for photovoltaic applications.

21. Single-Crystal Silicon (Czochralsky) – Silicon cells with a well-ordered crystalline structure consisting of one crystal (usually obtained by means of the Czochralsky growth technique and involving ingot slicing), composing a module. Ribbon silicon (as defined above) is excluded.

22. Transportation – Photovoltaic modules/cells used on boats, cars, and recreational vehicles; and those used for transportation support systems such as signs, illumination, warning signals, etc.

23. Utility – Photovoltaic modules/cells used to produce power at a utility owned system including central stations, decentralized systems or experimental applications.

24. Water Pumping – Photovoltaic modules/cells used for pumping water for agricultural, land reclamation, commercial and other similar applications where water pumping is the main use.

SPECIFIC INSTRUCTIONS

Specific instructions for most items are provided below. Self-explanatory items are not discussed.

Item	Instruction
1.2 (a)-(c)	Enter the name, title, and telephone number of an individual in the reporting company who may be contacted for additional information regarding this submission.
2.0	Mark as appropriate in 2.1(a) through 2.1(d) the manufacturing activity conducted by your company during the current reporting period.
3.1 (a)-(h)	Report only on activities that are photovoltaic related.
3.2 (a)-(g)	A new photovoltaic product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	"Full-time-equivalent" is defined as salaried employee time of at least 1,800 hours per year. Combined time of part-time employees meets the definition. Round to the nearest digit.
4.1 (1)-(2)	Enter the peak kilowatt value of photovoltaic modules/cells shipped (including exports and imports) in the appropriate module type column. Total should be the total peak kilowatts of all module/cell types. Concentrator modules shipments must be expressed in module kW not cell kW. Photovoltaic modules/cells for space applications are to be excluded.
4.2 (1)-(2)	The value reported should be total value received for modules/cells, at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar.
4.3 & 4.4	For each end-use category in questions 4.3 (1-8) and each market sector category in 4.4 (1-7), enter the peak kilowatts of producer shipments, by module type.
4.5	Enter the peak kilowatts by module type. This amount represents the portion of total producer shipments entered in 4.1 that were imported and shipped.
4.6	Enter the peak kilowatts by module type. This amount represents the portion of total producer shipments entered in 4.1 that were exported. Report modules in 4.5 (1) and cells in 4.5 (2).
4.7	List the country(ies) from which photovoltaic modules reported in question 4.4 were imported.
4.8	List the country(ies) to which photovoltaic modules and cells reported in question 4.5 were exported. List countries of destination for modules in 4.7 (1) and list countries of destination for cells in 4.7 (2).
4.9	Of the modules/cells reported in 4.1(1) and 4.1(2), report in peak kilowatts, the recipient of modules/cells immediately following manufacturing or warehousing. If recipients overlap (for example, the recipient is both a wholesale distributor and an installer), report the recipient in the higher category (i.e., a is higher than b, b is higher than c, etc.)
5.1	Enter the number of complete systems shipped from the total in 4.1(1)(h).
5.2	Of the modules/cells reported in 4.1(1) and 4.1(2), enter the peak kilowatts that were sold as complete systems. (Complete system is defined as a unit with all the necessary functional components except for installation materials.)
5.3	The value reported should be the total value received for the complete systems, at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. (It should include the value of the associated modules.) Do not include excise taxes, freight or transportation charges, or installation charges. Report values to the nearest dollar.
6.1	Mark as appropriate.
6.2	Mark as appropriate.
7.0	Self-explanatory.

Appendix C

Respondents to the Annual Solar Thermal Collector Manufacturers Survey

Appendix C

Respondents to the Annual Solar Thermal Collector Manufacturers Survey

Only 24 of the 44 respondents to the Annual Solar Thermal Collector Manufacturers Survey requested their names and addresses be published in this report.[5]

American Solar Networks, Ltd.
12811 Bexhill Court
Herndon, Virginia 22071

Applied Solar Products
4580-A Almaden Expressway
San Jose, California 95118

Aquatherm Industries, Inc.
1985 Rutgers Univ. Bldg.
Lakewood, New Jersey 27604

Caribe Sol De Puerto Rico
Apartado 190
Mayaguez, Puerto Rico 00709

Commins Power Generation, Inc.
500 Jackson St.
Columbus, Indiana 47202

Elbart Manufacturing Company
127 West Main
Millbury, Massachusetts 01527

FAFCO
235 Constitution Avenue
Menlo Park, California 94025

GS Energy Industries, Inc.
108 Jefferson Avenue
Des Moines, Iowa 50314

Heliodyne Corporation
4910 Seaport Avenue
Richmond, California 94804

Luz International, Inc.
924 Westwood Blvd., No. 1000
Los Angeles, California 90024

Nippon Electric Glass America, Inc.
3158 Des Plaines Ave., Suite 232
Des Plaines, Illinois 60018

Puerto Rico Solar Products
Apartado 702
Moco, Puerto Rico 00716

RADCO Products, Inc.
2877 Industrial Parkway
Santa Maria, California 93455

S and L Solar Systems
Apartado 1535
Carolina, Puerto Rico 00630

Sage Advance Corporation
1001 Bertelsen, Suite A
Eugene, Oregon 97402

Sealed Air Corporation
3433 Arden Road
Hayward, California 94545

Solahart U.S.A.
11855 Sorrento Valley Road
San Diego, California 92121

Solar Energy & Resources, Inc.
P.O. Box 2929
Bayamon, Puerto Rico 00621

Southwest Energy Tech, Inc.
3030 S. Valley View Blvd.
Las Vegas, Nevada 89102

[5]Note: The respondents requesting inclusion of their names and addresses are listed in this Appendix.

Sunearth, Inc.
4315 Santa Ana St.
Ontario, California 91761

Sun Glow Systems
P.O. Box 18324
Fountain Hills, Arizona 85268

Sun Quest, Inc.
155 Renker Ave.
Newton, North Carolina 28658

Thermomax USA, Inc.
23 Empire Drive Avenue
St. Paul, Minnesota 55103

Universal Solar Products, Inc.
Avenida Roosevelt 1108 Puerto Nuevo
San Juan, Puerto Rico 00920

Appendix D

Respondents to the Annual Photovoltaic Module Manufacturers Survey

Appendix D

Respondents to the Annual Photovoltaic Module Manufacturers Survey

Two of the seventeen respondents to the Annual Photovoltaic Module Manufacturers Survey requested their names be withheld from publication.[6]

Astro Power, Inc.
30 Lovett Ave.
Newar, Delaware 19711

CHRONAR
P.O. Box 177
Princeton, New Jersey, 08542

ENTECH, Inc.
P.O. Box 612246
Dallas/Ft. Worth Airport, Texas 75261

Hoxan America, Inc.
One Centennial Plaza, Suite 3F
Piscataway, New Jersey 08854

KYOCER America, Inc.
8611 Balboa Avenue
San Diego, California 92123

McCoy Industries, Inc.
7350 S. Trail, Suite 7
Sarasota, Florida 34231

Mobil Solar Energy Corporation
4 Suburban Park Drive
Billerica, Massachusetts 08121

Siemens Solar Industries
4560 Adhor Lane
Camarillo, California 93010

Solarex Corporation
1335 Piccard Drive
Rockville, Maryland 20850

Solec International
12533 Chadron Avenue
Hawthorne, California 90250

Solrtron International
P.O. Box 33249
Kerrville, Texas 78029

Sovonics Solar Systems
1100 W. Maple Road
Troy, Michigan 48084

Sunwatt Corporation
RFD Box 751
Addison, Maine 04606

Tideland Signal Corporation
P.O. Box 52430
Houston, Texas 77502

Utility Power Group
9410 Desoto Avenue
Unit G
Chatsworth, California 91311

[6]Note: Only those respondents requesting inclusion of their names and addresses are listed in this Appendix.

Glossary

Concentrator: A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.

Evacuated-Tube Collector: A solar thermal collector in which the collector fluid flows through an absorber tube that is contained inside an evacuated glass cylinder.

High-Temperature Collector: A collector that generally operates in the temperature range of over 180 degrees Fahrenheit.

Low-Temperature Collector: A collector that generally operates in the temperature range below 110 degrees Fahrenheit. Typically, it has no glazing or insolation and is made of plastic or rubber, although some are made of metal.

Medium-Temperature Collector: A collector that generally operates in the temperature range of 140 to 180 degrees Fahrenheit, but may operate at temperatures as low as 110 degrees Fahrenheit. Typically, it has one or two glazings, a metal frame, a metal absorption panel with integral flow channels or attached tubing (liquid collector) or with integral ducting (air collector), and insulation on the sides and back of the panel.

One Sun: Natural solar insulation falling on an object without concentration or diffusion of the solar rays.

Photovoltaic Module: A group of photovoltaic cells. Cells are solid-state devices used primarily in applications requiring remote power, such as radio communication, cathodic protection, and navigational aids.

Solar Thermal Collector: A device designed to receive solar radiation and convert it into thermal energy. Normally a solar thermal collector includes a frame, glazing, and an absorber together with appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use. Water, or water and antifreeze solutions are the most common working media for transferring heat from the collector. Air and special oils that operate at high temperatures are also used in many systems. Pool covers and other devices that do not involve the transport of energy via a working medium are not considered to be solar thermal collectors for the purpose of this survey.

Special Collector: An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature range from just above ambient temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

Survey Frame: The list of potential manufacturers of solar collectors or photovoltaic modules to which survey forms are sent.

Thermosiphon System: A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Your Entrée to
Federal Statistics!

CENSUS CATALOG AND GUIDE: 1990

Helps you select from all the products

Every Census Bureau product issued mid-1988--1989:
Reports Microfiche Computer tapes CD-ROM
Maps Floppy disks Online access

Key statistical publications from other Federal agencies (NEW!)

Features facts about each product

Topics Areas Dates Prices

Makes finding the right product easy

Extensive overview chapter Title index
Detailed subject index Guides to each statistical subject

Identifies sources of assistance

1,400 State Data Center organizations
200 Census Bureau specialists
1,500 depository libraries
Other Federal statistical agencies
4 other directory lists

Contents

General and Reference
Agriculture
Business
Construction and Housing
Foreign Trade
Geography
Governments
International
Manufacturing and Mineral Industries
Population
Transportation
1990 Census Product Plans (NEW!)
Sources of Assistance
Factfinder Guides

***6835** **Superintendent of Documents Publication Order Form**

Yes, please send me:_____copies of **Census Catalog and Guide: 1990** at $14, S/N 003-024-07169-0.

1. The total cost of my order is $ _____ . (International customers please add 25%.) All prices include regular domestic postage and handling and are good through 1/91. After this date, please call Order and Information Desk at 202-783-3238 to verify prices.

Charge your order. It's easy!

VISA

2. **Please Type or Print**

(Company or personal name)

(Additional address/attention line)

(Street address)

(City, State, ZIP Code)

(Daytime phone including area code)

3. **Please Choose Method of Payment:**

☐ Check payable to the Superintendent of Documents
☐ GPO Deposit Account ☐☐☐☐☐☐☐☐-☐☐
☐ VISA or MasterCard Account
☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

(Credit card expiration date) *Thank you for your order!*

(Signature) 8/90

4. **Mail To:** Superintendent of Documents, Government Printing Office, Washington, DC 20402-9325

Information

Information from the Federal Government on subjects ranging from agriculture to zoology is available at Depository Libraries across the nation.

You can visit these libraries and use the Depository collections without charge.

To find one in your area, contact your local library or write: Federal Depository Library Program, Office of the Public Printer, Washington, DC 20401.

Federal Depository Library Program

Energy Information Administration
U.S. Department of Energy
Forrestal Building, EI-231
Washington, DC 20585

THIRD-CLASS MAIL
POSTAGE & FEES PAID
U. S. DEPT. OF ENERGY
PERMIT NO. G-20

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

Do Not Forward, Do not Return
Address Correction Requested